The radical transbasal approach for resection of anterior and midline skull base lesions

Iman Feiz-Erfan, M.D., Patrick P. Han, M.D., Robert F. Spetzler, M.D., Eric M. Horn, M.D., Ph.D., Jeffrey D. Kloppenstein, M.D., Randall W. Porter, M.D., Mauro A. T. Ferreira, M.D., Stephen P. Beals, M.D., Salvatore C. Lettieri, M.D., and Edward F. Joganic, M.D.

Division of Neurological Surgery, Barrow Neurological Institute, St. Joseph’s Hospital and Medical Center, Southwest Craniofacial Center, Phoenix, Arizona; Division of Plastic Surgery, Mayo Clinic College of Medicine, Rochester, Minnesota; and Department of Surgery, Maricopa Medical Center, Phoenix, Arizona

Object. Craniofacial surgery can be performed to treat midline and anterior skull base lesions by creating a bicoronal scalp incision without the need for an additional transfacial procedure. Originally described as the transbasal approach, several modifications for further exposure of the skull base have been described. The authors present data on the application and outcomes of a modified transbasal approach. The radical transbasal approach consists of a bifrontal craniotomy and a frontoorbitonasal osteotomy.

Methods. Between 1992 and 2002, 41 patients (28 male and 13 female patients with a mean age of 38.3 years [range 7–77 years]) underwent 44 radical transbasal procedures. Twenty-three malignant and 18 benign lesions involving the midline skull base were treated. These cases were reviewed retrospectively.

Gross-total resection of 30 lesions was achieved. Seven lesions were resected subtotaly and six partially; one lesion was debulked. Complications occurred in 26 (59.1%) of the 44 operations and mostly consisted of cerebrospinal fluid leakage. The surgery-related mortality rate was 6.8% (three patients). Based on their pre- and postoperative Karnofsky Performance Scale scores, 86.4% of patients improved or remained the same.

Conclusions. The radical transbasal approach increases the midline craniofacial corridor by allowing the globes to be safely retracted laterally. It also enhances exposure of the maxillary sinus from above. The morbidity and mortality rates associated with this procedure are high but consistent with the known rates for craniofacial surgery. This approach is best suited for the treatment of anterior skull base tumors that extend into the nasal cavity, orbit, ethmoid sinus, nasopharynx, and upper clivus. The approach may allow resection of tumors involving the maxillary sinus area without the need for an additional transfacial approach.

Key Words • craniofacial surgery • transfrontonasoorbital approach • anterior fossa • sinonasal cavity

The resection of mass lesions with a significant extradural component involving the anterior skull base and the sphenethmoidal complex was significantly enhanced by the introduction of an extradural approach to the anterior cranial base through a bicoronal scalp incision coupled with a bifrontal craniotomy. This approach, originally used by Unterberger9 in 1958 to repair traumatic lesions of the frontal skull base, was subsequently applied by Tessier and colleagues37 to correct craniofacial anomalies. Finally, Derome12 introduced it to surgery for skull base tumors, in which it is referred to as the transbasal approach.

Tumors with a significant extension along the anterior skull base, orbits, sinuses, nasal cavity, and clivus can be resected more radically but also more safely by using this approach because the surgeon can better control the contents of the cranium compared with using transfacial procedures to access the same territory. Critical neurovascular structures are better visualized and protected throughout the course of resection. Removal of bone along the anterior skull base minimizes risks of brain damage related to retraction.

This concept led to further modification of the original transbasal approach. The orbital bar was removed in a variety of ways by using the extended frontal, transfrontal, midline supraorbital, frontal sinus intracranial, glabellar, transsphenoidal, telecanthal, enlarged transbasal, extensive transbasal, extended transbasal, or extended subfrontal approach.1–3,10,12,13,16–18,22,27,32,33,36,38 By adding nasal osteotomy to the removal of the orbital bar, brain retraction is further minimized and visualization of the caudal extension of mass lesions is improved. This modification has been called the transfrontonasal, transglabellar–subcranial, subcranial, modified subcranial, extended transbasal, extended subcranial, subfrONTAL, or extended anterior subcranial approach.1–3,9,13,19,21,25,28–31,34

In this article we describe our clinical experience with a more extended form of the original transbasal approach, originally published elsewhere as the “transfrontal–nasoorbital approach.”1–3,13 By adding bilateral osteotomies to

Abbreviations used in this paper: CSF = cerebrospinal fluid; KPS = Karnofsky Performance Scale.
both the lateral and medial orbital walls, the entire frontonasoorbital bar can be removed after a bifrontal craniotomy has been performed (Fig. 1). The lateral retraction of both globes (Fig. 2A), which is facilitated by the osteotomies, provides the widest possible exposure of midline and para-median skull base structures and enhances the exposure of the maxillary sinus through a midline craniofacial procedure, which evolved from the transbasal approach. Hence, this modification is called the radical transbasal approach.

Clinical Material and Methods

Twenty-eight patients were included in a previous report of our overall experience with craniofacial and transfacial approaches to midline skull base lesions. In the current report we describe our entire experience with the radical transbasal approach. Between 1992 and 2002, 41 patients (28 male and 13 female patients) ranging in age from 7 to 77 years (mean age 38.3 years) underwent a total of 44 radical transbasal approaches for a variety of midline skull base lesions with or without an intradural extension (Table 1). The patients’ charts were reviewed retrospectively. Office visit notes or phone calls to patients or their primary physicians were used to obtain follow-up information. All lesions were resected by a team consisting of neurosurgeons (R.F.S. and R.W.P.) and craniofacial surgeons (S.P.B., S.C.L., and E.F.J.). Preoperatively, the patients’ KPS scores ranged from 50 to 90 (mean score 85).

Surgical Technique

This procedure is described in detail elsewhere but we provide a summary. The patient is placed supine with the head in the neutral position and secured in three-point fixation. The skull pins are located posterior to the bicoronal incision site. A bicornal scalp incision is made 13 to 15 cm from the orbital rim. The pericranium is left intact and elevated separately for later skull base and dural reconstruction.

A bicornal craniotomy is performed in a standard fash-
Radical transbasal approach to the skull base

TABLE 1
Types of skull base lesions in 41 patients

<table>
<thead>
<tr>
<th>Histology of Lesion</th>
<th>No. of Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>juvenile angiofibroma</td>
<td>9 (21.9)</td>
</tr>
<tr>
<td>esthesioneuroblastoma</td>
<td>4 (9.8)</td>
</tr>
<tr>
<td>adenoid cystic carcinoma</td>
<td>3 (7.3)</td>
</tr>
<tr>
<td>sinonasal undifferentiated carcinoma</td>
<td>3 (7.3)</td>
</tr>
<tr>
<td>rhabdomyosarcoma</td>
<td>2 (4.9)</td>
</tr>
<tr>
<td>pituitary adenoma</td>
<td>2 (4.9)</td>
</tr>
<tr>
<td>squamous cell carcinoma</td>
<td>2 (4.9)</td>
</tr>
<tr>
<td>ossifying fibroma</td>
<td>2 (4.9)</td>
</tr>
<tr>
<td>adenocarcinoma</td>
<td>2 (4.9)</td>
</tr>
<tr>
<td>small cell neuroendocrine carcinoma</td>
<td>2 (4.9)</td>
</tr>
<tr>
<td>mucosal melanoma</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>ganglioneurofibroma</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>hemangioma</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>encephalocele</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>osteosarcoma</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>chordoma</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>chondrosarcoma</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>mesenchymal chondrosarcoma</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>odontogenic myxoma</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>meningioma</td>
<td>1 (2.4)</td>
</tr>
</tbody>
</table>

ion by creating burr holes over both pterional regions and on each side of the superior sagittal sinus. Osteotomy of the frontonasoorbital block, including the orbital rim, lateral and medial orbital walls, orbital roofs, and nasal bone, is performed with the aid of a reciprocating saw and osteotomes (Fig. 1A and B).

The reciprocating saw is inserted within the orbit. The cut begins at the infraorbital fissure and proceeds outward toward the temporal fossa, parallel to the orbital roof. Next, the saw is placed into the infraorbital fissure from the temporal fossa and a cut is made at a 90° angle to the frontal fossa. The middle fossa should not be violated. From intracranially, this cut is continued across the frontal fossa to the posterior margin of the cribriform plate. The saw is turned 90° anteriorly to cut along the lateral margin of this plate. The saw is turned another 90° to cut along the anterior margin of this plate. The contralateral cut is made in the same fashion.

To incorporate the nasal bone and medial orbital walls within the frontonasoorbital bar, the saw is inserted within the piriform aperture. Cutting proceeds upward from the piriform aperture and crosses the upper portion of the lacrimal fossa to end at the level of the anterior ethmoidal artery. The artery must be cauterized and cut before the osteotomy begins. Furthermore, the lacrimal gland must be elevated from the lacrimal fossa and temporarily retracted to avoid injuring the gland during the osteotomy. Finally, a narrow osteotome is placed along the anterior border of the cribiform plate at a 90° angle to the frontal fossa. A few gentle strokes with a hammer will detach the osseous portion of the nasal septum bar from the nasal vault.

Before the osteotomies are performed, the medial canthal ligaments are detached from the sites of their insertion in the bone by using periosteal elevators. The ligaments are later wired into position with 28-gauge wire. The globes are retracted laterally (Fig. 2A). If the cribiform plate is not involved with the pathological entity, preservation of olfaction can be attempted by using a circumferential cribiform plate osteotomy as described elsewhere.\textsuperscript{35} We use stereotac-

![Fig. 3. Artist’s drawings showing steps involved in closure. A: Two 28-gauge wires are passed across the top of the nasal vault through two small holes drilled immediately behind and at the cranial rim of the lacrimal fossa. The wire ends are fed through the skin through an 18-gauge needle. The wires are then passed from the inside outward through needle punctures placed above and below each medial canthal tendon (purchase sites are labeled a, b, c, and d). B: The skin bridge between the wires is cut with a No. 15 blade without damaging the medial canthal tendon, which lies subcutaneously. The pair of wires on the right is twisted four times in a clockwise direction by using a needle holder. C: The Tessier wire-passer awl is used to press against the overlying soft tissue, and a needle holder is used to place continuous traction on the contralateral wire pair while the wires are tightened. While the wires are pulled tight, the contralateral pair of wires is twisted clockwise four turns. The Tessier wire-passer awl is then removed, and the untwisted ends of the wires are trimmed. D: A hemostat is used to bury the twisted wire ends in the subcutaneous tissue. The skin bridges are closed with a single subcuticular stitch using 5-0 absorbable material.](image-url)
of the facial bones with miniplates and screws. The wires are tunneled through the skin above and below the medial canthal tendon located in the subcutaneous tissue. This maneuver is performed using an 18-gauge needle to perforate the skin above and below the medial canthal tendon from the outside in. The top wire is tunneled through the upper skin perforation, and the lower wire is tunneled from below the medial canthal tendon (Fig. 3A). This procedure is repeated on the contralateral side.

On each side the skin bridge between the two wires is cut in a curvilinear fashion by using a No. 15 blade. The medial canthal ligament, which is located subcutaneously, must not be cut. A needle holder is used to twist the two wires on one side clockwise four turns (Fig. 3B). The Tessier wire-passer awl is threaded over both wires on the contralateral side, and the wires are pulled while the awl is pushed against the bone at the contralateral side (Fig. 3C). The wires are buried within the subcutaneous tissue. The small skin incision is closed using a 5-0 monofilament suture (Fig. 3D).

The surgical defect, dura mater, and skull base are reconstructed using local or, if needed, distant vascularized flaps, fat grafts from the abdomen, fascia lata, and split calvaria autografts. Rarely, foreign material in the form of bone cement or titanium mesh is used. If the risk of CSF leak is high, a lumbar or ventricular drain can be placed.

Results

Altogether, 23 malignant and 18 benign lesions were treated. Twenty-seven lesions had both extra- and intradural components. As evidenced by postoperative magnetic resonance imaging of the head and by the surgeons’ intraoperative inspection after tumor resection, gross-total resection was achieved in 30 cases. Subtotal (95–99%) resection was attained in seven cases, partial (75–95%) resection in six cases, and debulking (75% resection) in one case.

Additional approaches were needed in 18 patients to resect residual disease and to perform an extracranial–intracranial bypass when necessary. Twelve additional approaches were combined in the same setting and six were staged. For the combined approaches, a transfacial procedure was added to resect a lesion that was located more laterally in the upper corners of the maxillary sinus. Sixteen lesions had a significant extension to the maxillary sinus and lower nasal cavity. In 10 of these cases, an additional transfacial approach was needed to remove the tumoral extension. In six cases the tumor was removed completely from the maxillary sinus and nasal cavity under direct microscopic visualization via the transcral exposure. Anterolateral approaches were added for diseases involving the middle fossa, infratemporal fossa, or cavernous sinus. Eleven procedures were performed for recurrent or progressive disease despite previous therapy (Fig. 4). One patient underwent two repeated operations, and another patient underwent one additional operation through the same approach. Periopera-

I. Feiz-Erfan, et al.

![Image](image.png)
Radical transbasal approach to the skull base

- Lumbar drains were inserted in 20 cases and external ventricular drains in 13 cases.
- There were three surgery-related deaths (6.8%, defined as death ≤ 30 days of the procedure or during the same hospitalization). Surgery-related complications occurred in 26 cases (59.1%, Table 2). After surgery, no patient experienced a decline in vision, which could have been caused by lateral retraction of the globes. By adding a cribiform plate osteotomy in selective cases, olfaction could be preserved in most cases.

- The mean hospital stay was 14.1 days. Thirty-eight patients were discharged home. Four patients went to a rehabilitation facility, and two patients required transfer to an extended care facility after discharge.

- The mean postoperative KPS score was 82.5 (range 0–100). Based on a comparison of the pre- and postoperative KPS scores, 38.5% of the patients improved, 47.9% remained unchanged, and 13.6% were worse after surgery.

Long-term follow-up review (mean 40.2 months, range 1–108 months) was available in all but one patient.

Discussion

The radical transbasal approach can be considered the most extensive variation of a transbasal approach. The orbital rim, orbital roofs, medial orbital walls, and nasal bone can be removed as described in other extended forms of the transbasal approach. Nevertheless, the radical transbasal approach offers a wide corridor into the sinusal complex by including osteotomies of the lateral orbital walls bilaterally, thereby facilitating lateral retraction of the globes (Fig. 2A). We have not noted any decline in vision related to retraction of the globes laterally, a maneuver thought to be hazardous to the orbit and optic nerves. We believe, however, that sectioning the lateral orbital walls makes it safer to retract the orbit contents laterally by minimizing retraction pressure exerted on the orbital contents (Fig. 2). Furthermore, better surgical visualization and access to the maxillary sinuses, which is more limited in the transbasal approach and in its extended modifications, can be gained.

Lesions with extension to the upper lateral corners of the maxillary sinus, cavernous sinus, infratemporal fossa, and dorsum sellae require additional exposure through transfacial, anterolateral, or lateral skull base procedures. Such exposures were needed in 18 of our patients. Midline lesions that have an epicenter within the middle or lower clivus without an intradural component are best resected through a transbasal approach. The transbasal approach and its variety of extended modifications permit access to pathological entities in the lower clivus and foramen magnum; entities in the lower clivus and foramen magnum; series of anterior craniofacial surgery, complication rates may reflect the extensive nature of the diseases we treated, as exemplified by the 27 patients who required intra- and extradural dissection to resect their lesions. The extensive dissection likely contributed to the most common complication, CSF leakage.

In our series the incidence of cerebrovascular accidents was high. This complication reflects the extensive association of the tumor with major arteries located at the skull base as well as with small perforating branches of major arteries leading to iatrogenic vascular injury during dissection in the subarachnoid cisterns. A postoperative blow out of the carotid artery also occurred in one case. At follow-up examinations, however, most patients physically remained the same or experienced improvements in their symptoms, as seen in the comparison of their pre- and postoperative KPS scores and long-term follow-up clinical evaluations.

Conclusions

The radical transbasal approach, which consists of a bifrontal craniotomy with a frontonasoorbital osteotomy that includes the orbital rim, medial and lateral orbital walls, orbital roofs, and nasal bone, opens a wide midline craniofacial corridor. It thereby enhances the surgeon’s access to the orbits, sinonasal compartment, and skull base. In particular, there is improved surgical visualization of the upper maxillary sinus area, which is considered a blind spot in transbasal and extended transbasal approaches.

Midline skull base tumors can be resected aggressively by using this approach. The complication rate is high, but permanent clinical deterioration is rare. Patients who harbor an extensive midline skull base lesion with a primary extradural component, with or without an intradural extension to the anterior skull base, are good candidates for this procedure.

References

1. Beals SP, Joganic E: Transfacial exposure of anterior cranial fossa and clival tumors. BNI Quarterly 8:2–18, 1992

J. Neurosurg. / Volume 103 / September, 2005

489


